Development of a Deployable Wastewater Treatment System for Forward Operating Bases

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May 12, 2011

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
12 MAY 2011		**00-00-2011 to 00-00-2011**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Development of a Deployable Wastewater Treatment System for Forward Operating Bases	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army Engineer Research and Development Center,Construction Engineering Research Laboratory,PO Box 9005,Champaign,IL,61826-9005**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 9-12 May 2011 in New Orleans, LA.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**21**	

Wastewater Treatment Issues at FOBs & Disaster Locations

- Wastewater treatment requires space, energy, and personnel.
- Delivery of water and offsite treatment of wastewater
  - requires fuel for transport
  - exposes personnel to danger
  - every delivery truck is a security threat
- Delivery of wastewater to treatment plants and equilibration of flow
  - Sewer lines may be nonexistent, severely damaged, or flooded
  - Flow needs to be equilibrated
  - Storage can be in tank, lined pit, or large bladder.

Wastewater Treatment Issues at FOBs and Disaster Locations

- Population may be using portable outhouses or latrine pits.
  - Vacuum truck(s) may be needed to transport sewage to centralized location for treatment.
  - Deodorizers and disinfectants used in portable toilets can drastically impact ability to treat wastewater.
  - High concentration wastewater/solids.
- Fate of treated effluent?
  - Flow to any water body.
  - Can be reused for non-potable purposes.
  - Discharge can be problematic due to geography.
- Weather

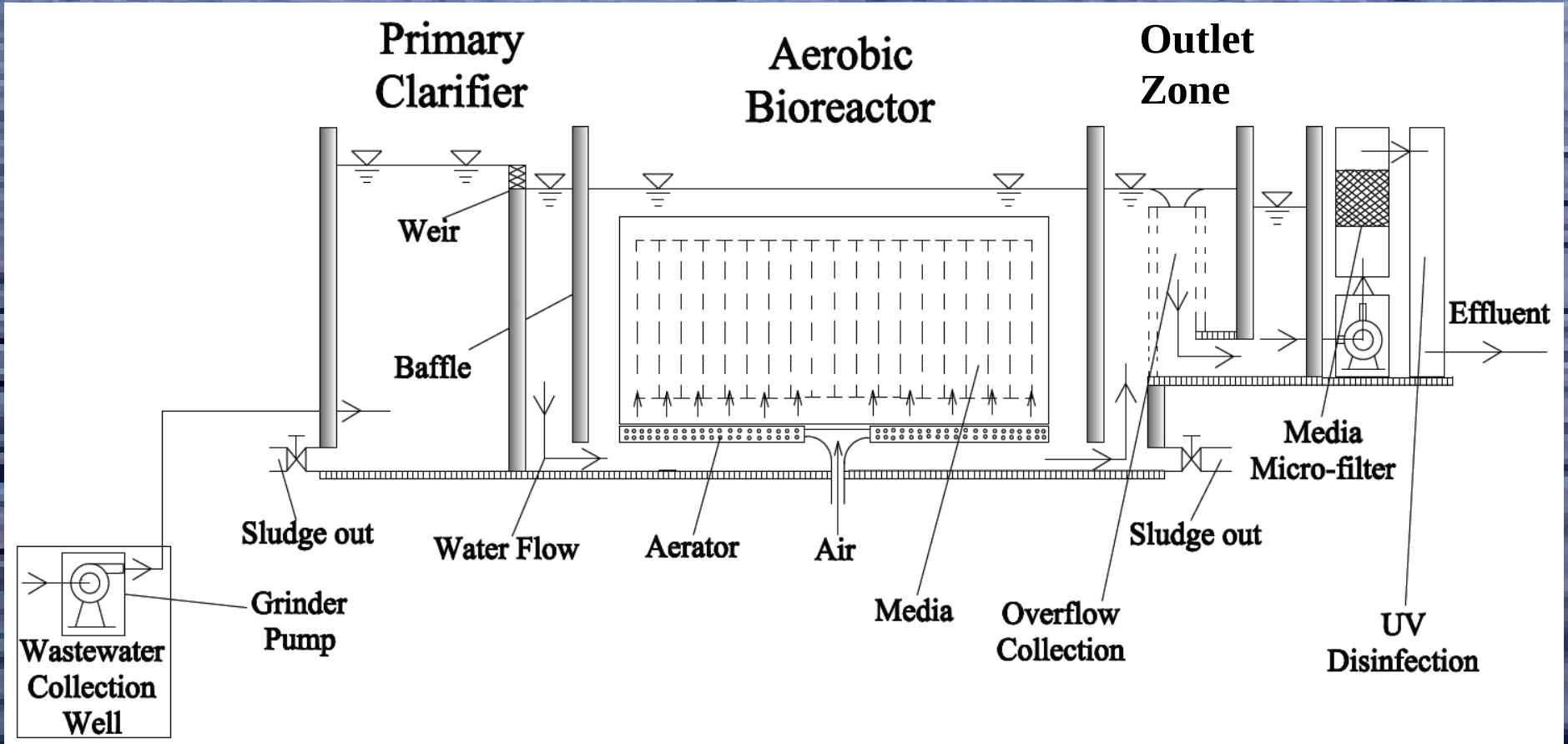
Army Goals

- Zero bootprint FOB/NetZero Installations
- Reduce/eliminate energy required for wastewater treatment
  - Reduce overall energy demands
  - Produce energy from wastewater
- Reduce need for potable water transport
  - Reuse wastewater to maximum extent for nonpotable purposes
  - Reuse wastewater for potable purposes

Deployable Aerobic Aqueous Bioreactor (DAAB) Goals

- Operate in austere environments
  - FOBs
  - Disaster relief
- Easily transported
- Rapid startup
- Minimize support requirements
  - Operator training and time
  - Energy
  - Supplies

Basic Flow Diagram

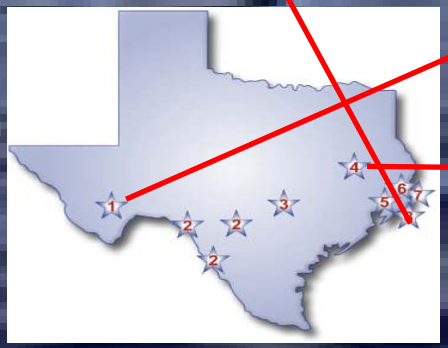


Gravitational flow after wastewater intake.

Prototype Demonstration Sites

Beaumont, TX

Alpine, TX



Huntsville, TX

DAAB vs. Activated Sludge

Parameters	DAAB System	Conventional Activated Sludge	Extended Aeration System
Organic Loading ($kg\text{-}BOD_5\ m^{-3}day^{-1}$)	0.3-0.5	0.3-0.6	0.2-0.4
HRT (hr)	7-15	4-10	18-36
Recycle Ratio	-	0.3-1.0	0.7-1.5
Depth, m	2	1.5-5.0	1.5-5.0
$Kg\text{-}O_2/Kg\text{-}BOD_5$	1.1	1.2	2.2
R % (BOD)	80-95	85-95	75-95
Sludge Production	Minimal	Medium	Low

Biofilm Pros and Cons

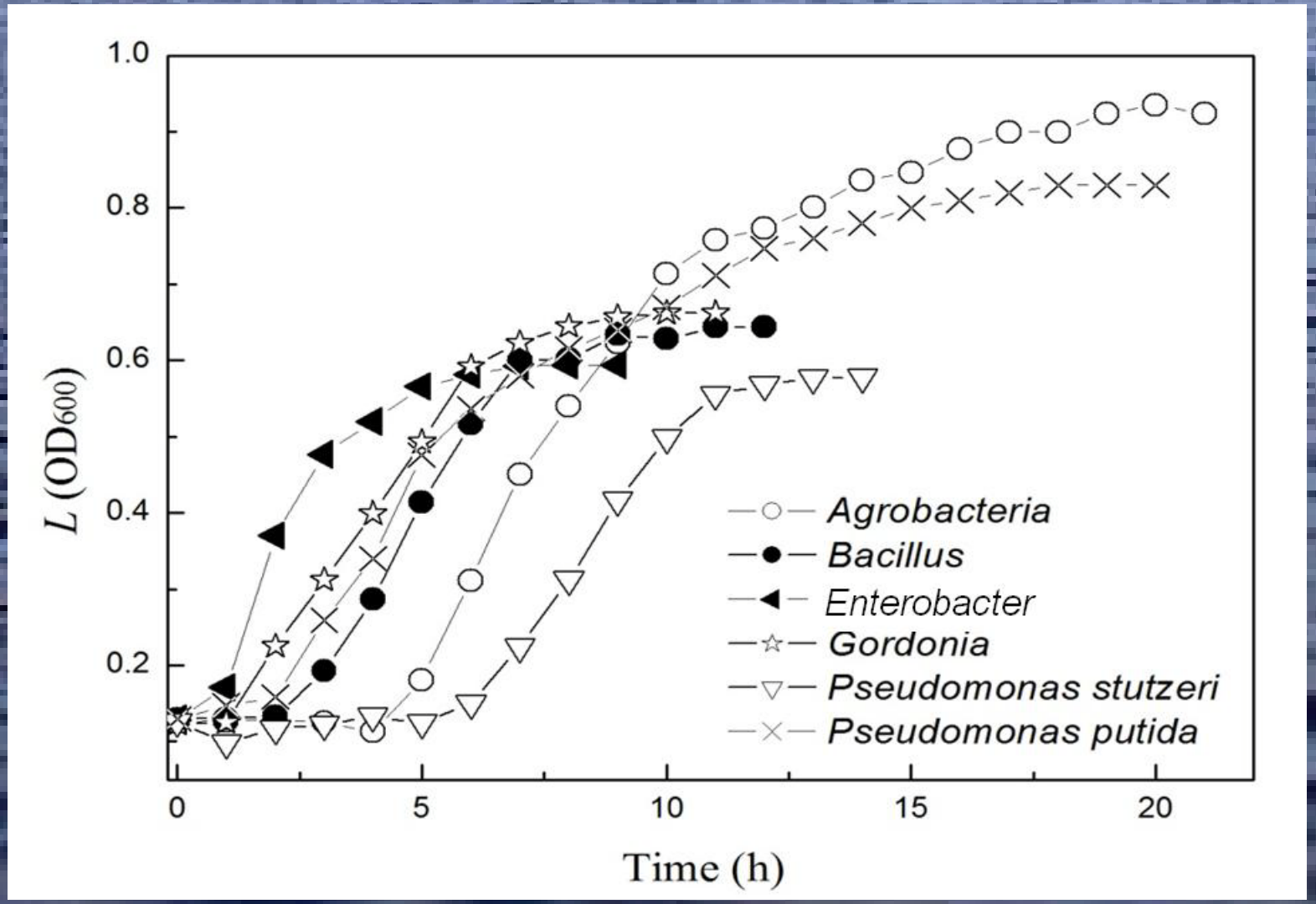
PROS

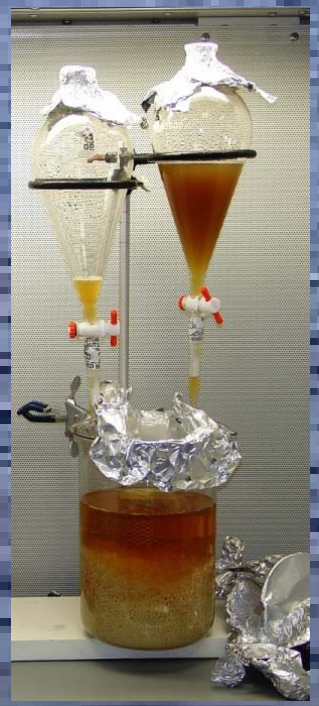
- Biomass will not washout due to hydraulic overload
- Resistant to chemical shock
- Simplified operation requirements
- Reduced sludge production

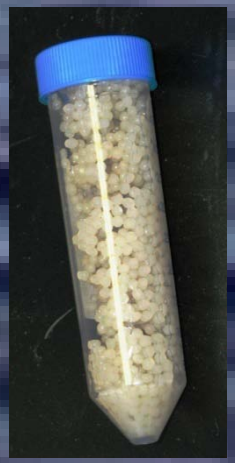
CONS

- Slightly lower treatment rate
- Good biofilm establishment can be tricky

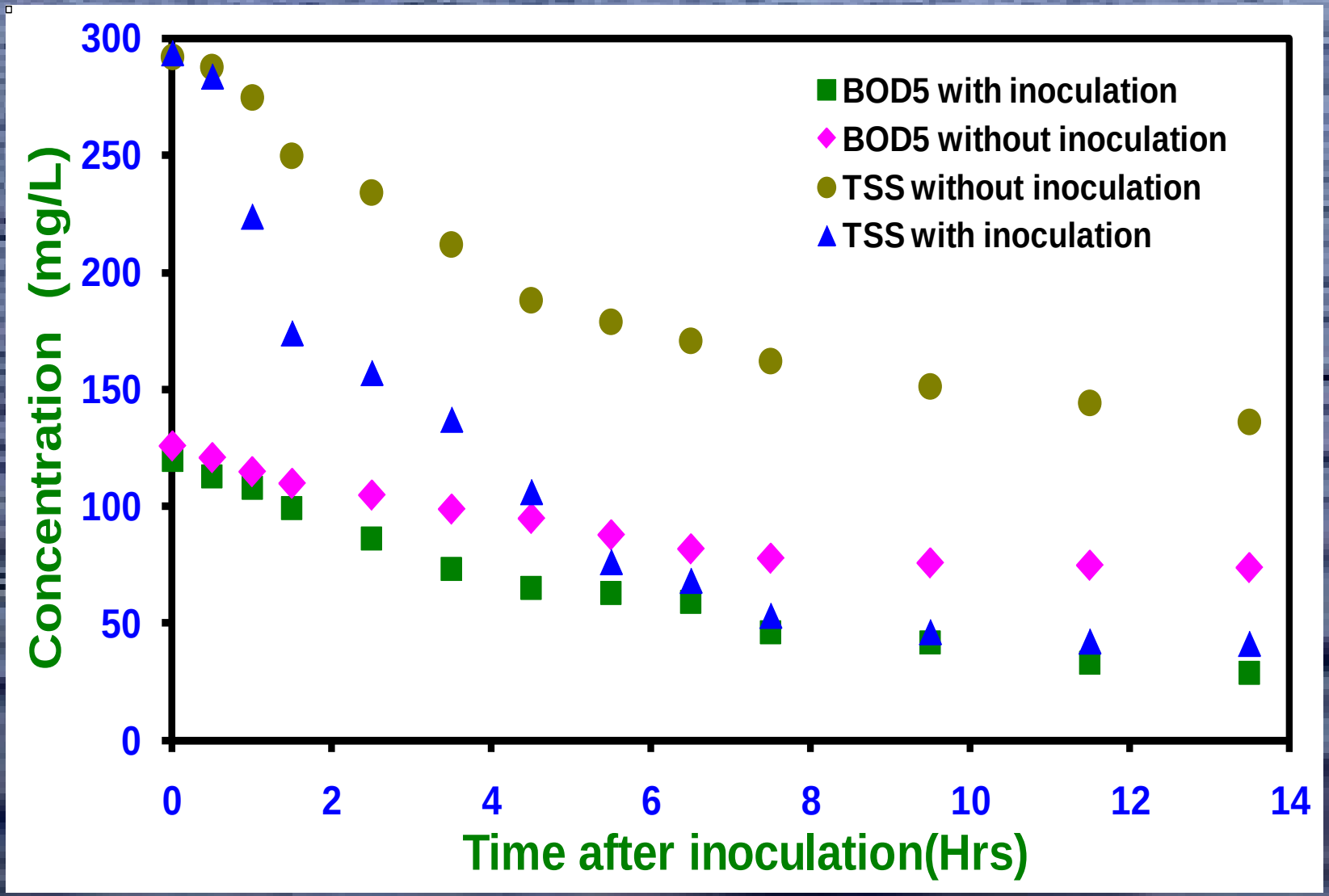
Biofilm Cultures



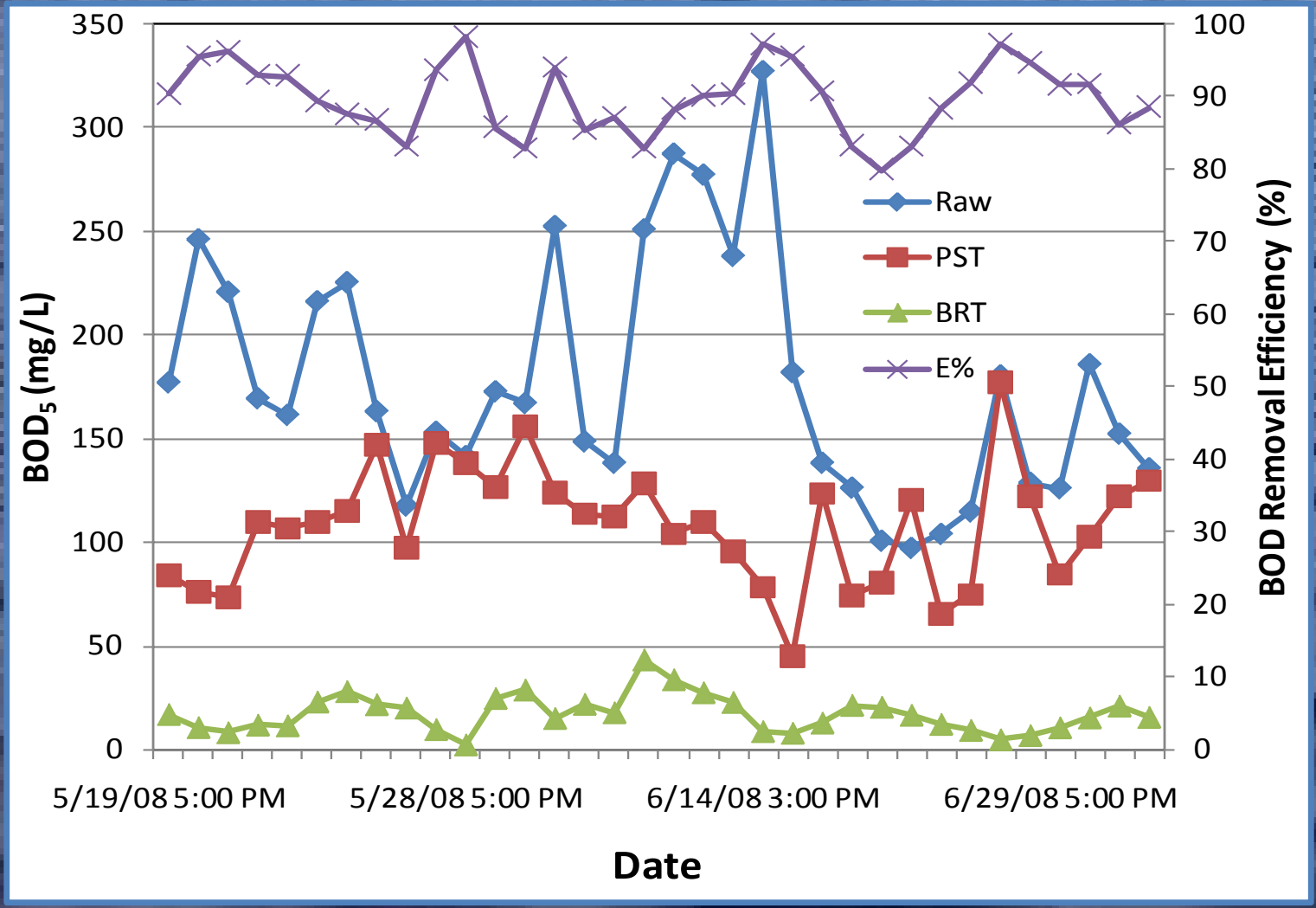




Impact of the Consortium

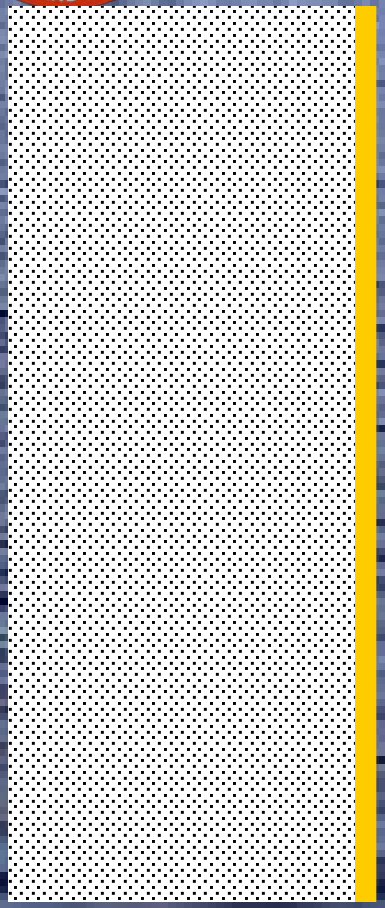


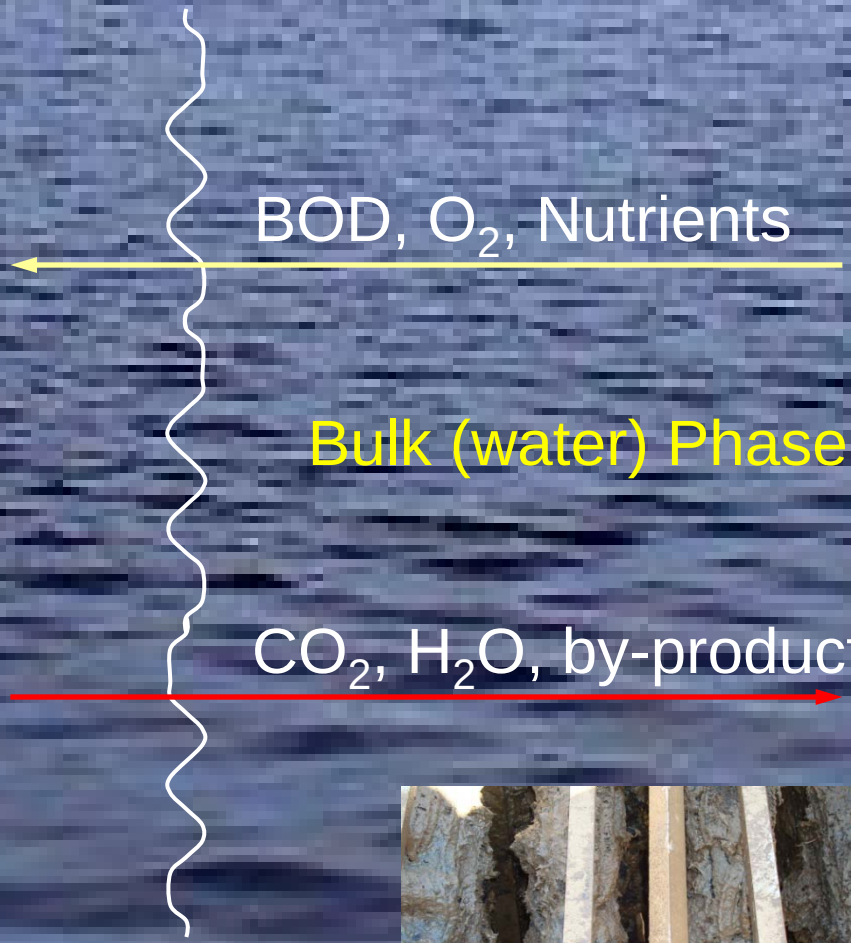
System Performance

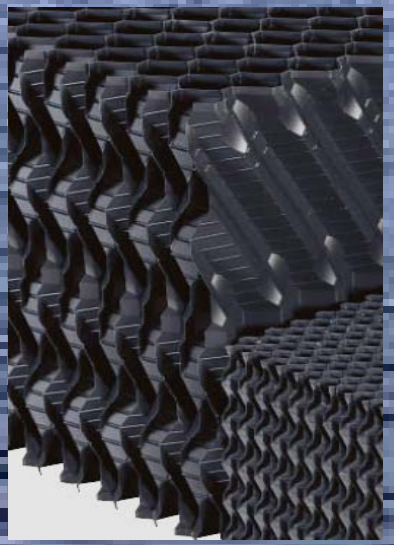


(Continuous flow at 7500 gal/day)

DAAB – a Biofilm Process



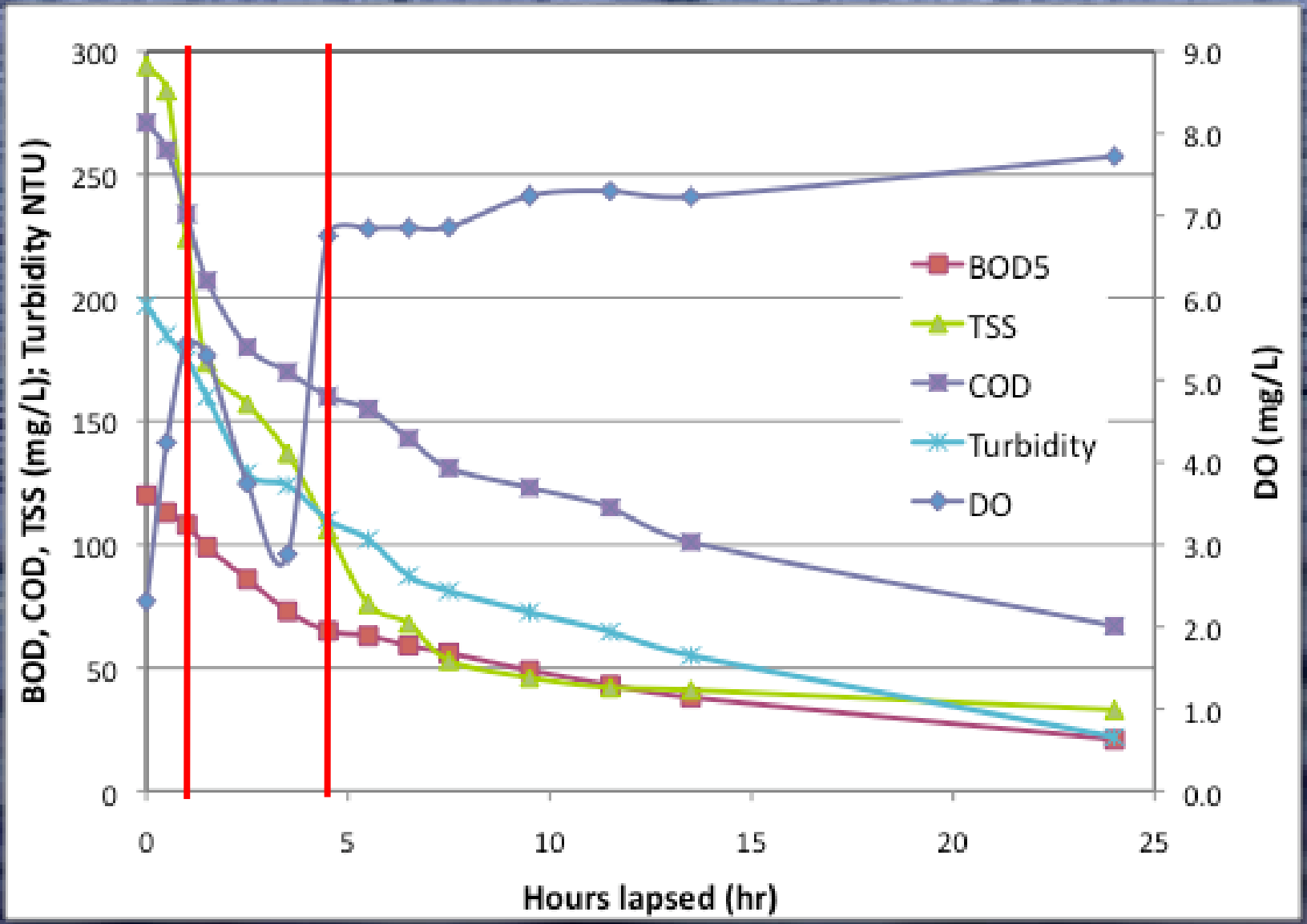




Media

Biofilm

Startup in Bioreactor



Basic DAAB System

Biological Treatment Unit "BTU"

Wet Unit

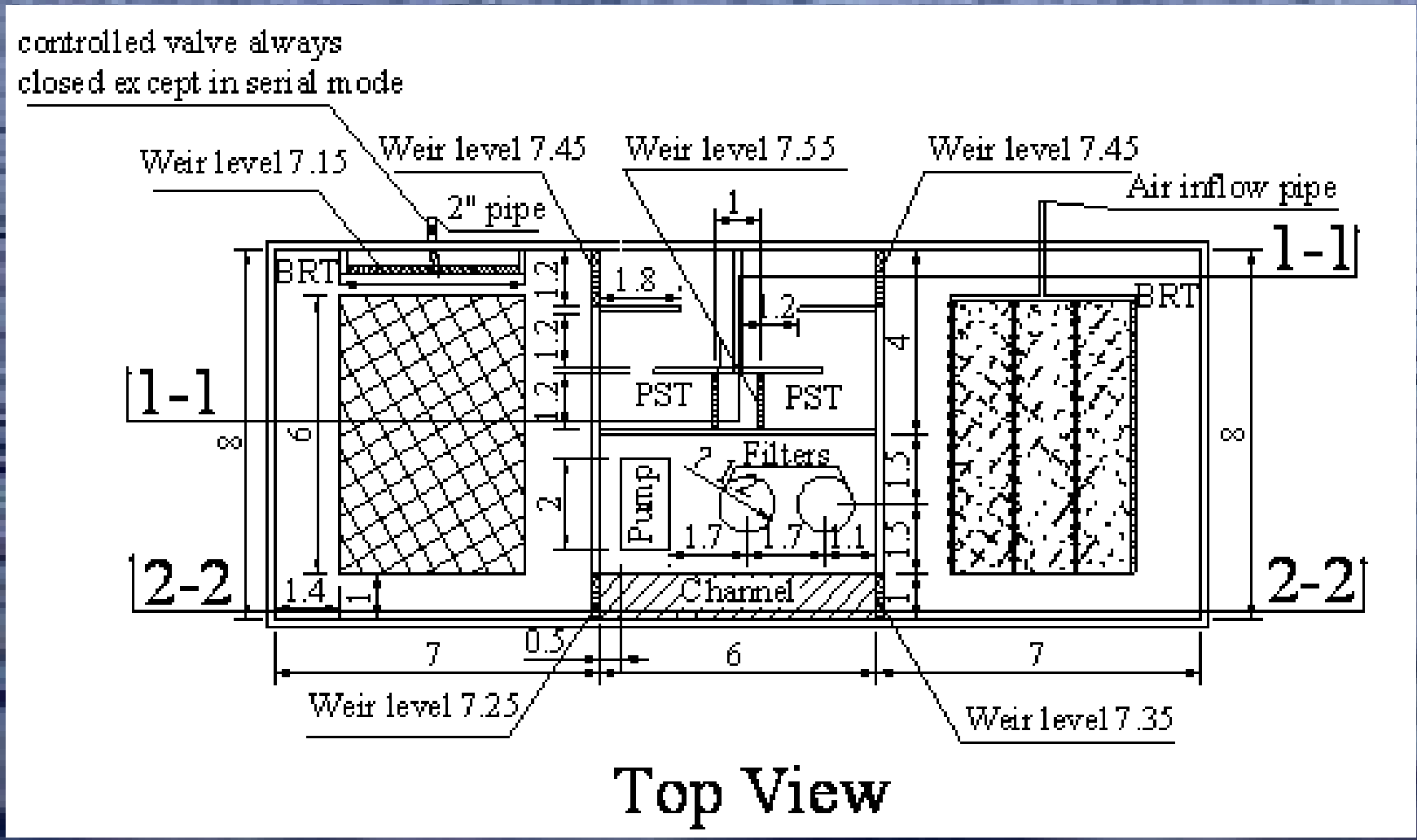
- Water intake – grinder pump
- Primary sedimentation tank
- Aerobic bioreactors
- Aeration blowers

Control and Power Unit "CPU"

Dry Unit

- Control systems
- Biological amplification tanks
- Diesel power generator
- Mulimedia filter system
- UV disinfection system

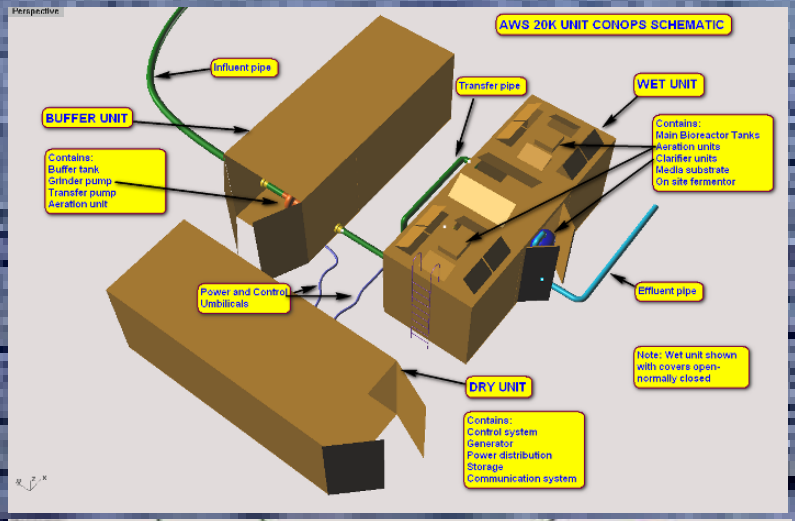
The “Wet” Unit

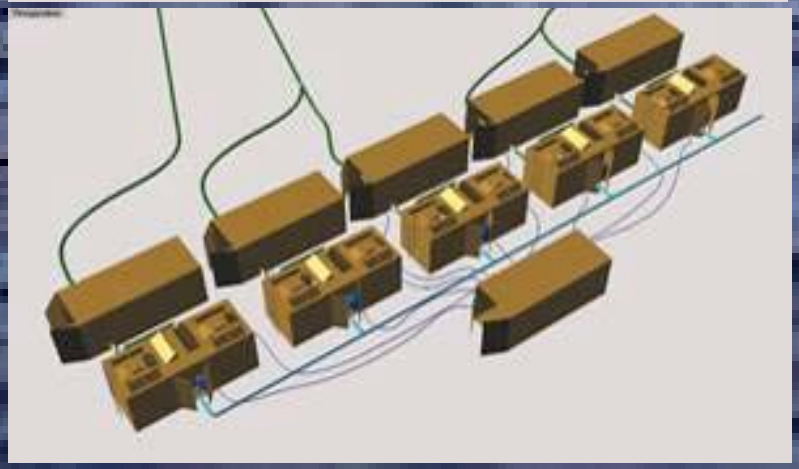


Top View

Synthetic growth media with bottom aeration.

Deployable Aerobic Aqueous Bioreactor (DAAB)





DAAB shipping to Afghanistan

6 commercial units based on the DAAB design were shipped to Afghanistan by the Army in 2010.

Biological Treatment Unit (BTU)

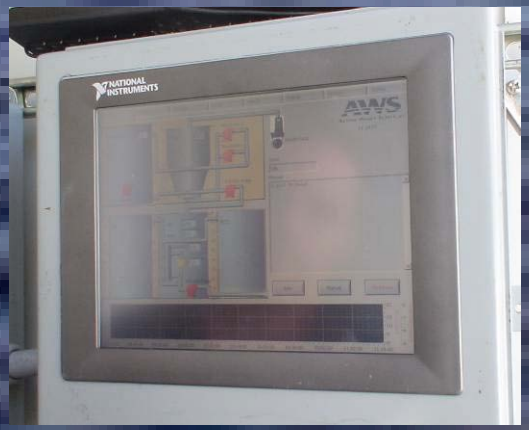
Access to blowers and control relays


Access port to primary sedimentation tank


Access ports to 1 of 2 aeration tanks

Control & Power Unit (CPU)

Control side:
- *control center*
- *Fermenter*
- *refrigerator for biological seed*



Power side:
- *30 kW diesel generator capable of powering 4 BTUs*
- *filtration unit with automated backwash*

Project Outcomes

- Prototype built to meet military shipping requirement (U.S. DoD 4500.9-R) and operates in one 40-foot or two 20-ft ISO containers.
  - 20-ft ISO containers can be delivered by HEMTT w/PLS
- Treats 20,000 gal/day of municipal wastewater within 48 hours of placement.
- One CPU can support up to 3 BTUs.
- Meets USEPA municipal wastewater discharge requirements, BOD & TSS < 30 mg/L (< 20 typical before filtration)
- Successful demonstrations at domestic sites
- Six units based on DAAB design deployed to Afghanistan
- Estimated capital costs: $146k/CPU, &188k/BTU

Ongoing/Future R&D

- Electrochemical disinfection unit
- Pharmaceuticals – removal kinetics and efficiencies
- Impact of portable toilet chemicals on DAAB
- Wastewater equilibration and intakes
- Development of design that deploys in TRICONs, which can be helilifted
- Energy reduction
  - Low pressure membrane filtration unit (ultrafiltration) to replace multimedia filtration
  - Microbial fuel cells to replace one of the BTU aeration tanks